National Bureau of Standards

June 1957
Volume 41
Number 6

Technical News Bulletin

PUBLIC LIBRARY
JUN 21 1957
DETROIT

U.S. 9.3 St6T

ULTRA-HIGH-STRENGTH STEEL

THE NATIONAL BUREAU OF STANDARDS has experimentally produced an ultra-high-strength steel that can be heat-treated to a strength of 285,000 lb/in.^{2} with sufficient ductility for structural applications. Developed by Samuel J. Rosenberg and Carolyn R. Irish [1] of the Bureau's thermal metallurgy laboratory, the steel is made by normal melting and working processes and should not be difficult to manufacture.

In recent years the increasing demand for reduced weight in aircraft structures has been a constant stimulus for the development of high-strength steels. One of the principal applications for such materials is in aircraft landing gears. Because landing gears constitute approximately 10 percent of the weight of an empty military plane, the use of an ultra-high-strength steel in such components can save considerable dead weight with a corresponding increase in load-carrying ability. Because of the urgent need for stronger steels in this particular application, the Navy Bureau of Aeronautics has sponsored an investigation at NBS to develop a steel having a tensile strength of approximately 300,000 lb/in.^{2}

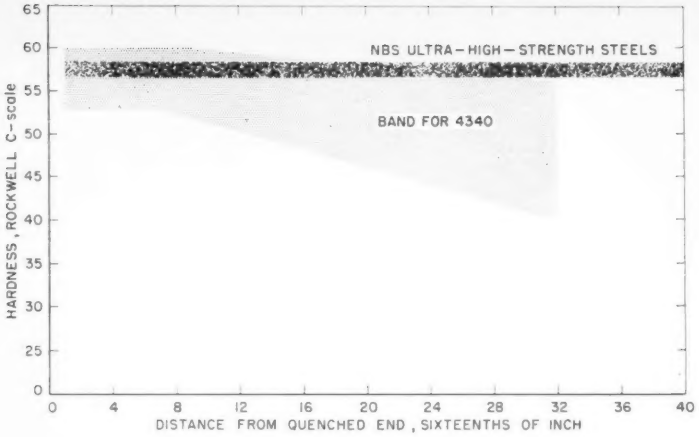
Although many steels can be heat-treated to strengths of 300,000 lb/in.^{2} and higher, they are normally quite brittle at this strength level. Such brittleness prohibits their use in structural applications where a certain amount of ductility and toughness is required. The present investigation therefore concentrated on developing a steel that would not only be strong but would also have high impact resistance.

Preliminary considerations indicated that the strength level desired could not be obtained in structural steel containing less than about 0.40 percent of carbon if the steel were to be given some form of tempering treatment subsequent to hardening. In addition, the steel would require considerable amounts of alloying elements in order to transform completely to martensite so that large components, such as landing-gears, could be hardened throughout. The experimental steels were therefore based on AISI 4340 modified as desired. Boron was added to a split of each melt as previous studies [2] had indicated that boron increases hardenability and has a beneficial effect upon the impact properties of some steels at room temperature and below.

Over 40 experimental steels were melted in the Bureau's foundry. These were forged and rolled into $^5/_8$ in., $^7/_8$ in., and $1^1/_4$ in. plates, which were then normalized and annealed. Tensile, Charpy impact (V-notch), and Jominy (end-quench) hardenability specimens were machined from the different thicknesses. The tensile and impact specimens were heat-treated by six different methods, and the tensile, impact, and hardness properties of the various specimens then determined.

One particular composition appeared to have an excellent combination of strength and ductility. This was a steel based on AISI 4340 modified by the addition of silicon and titanium. Additional melts were made to check the results obtained on specimens from

426470—57



End-quench hardenability band for two of the NBS ultra-high-strength steels superimposed on the hardenability band of AISI 4340 steel. The high level of hardenability of the NBS steels is indicated by the constant hardness from the quenched end, where the rate of cooling is extremely fast, to 2½ in. from the quenched end, where the rate of cooling is quite slow.

the original steel. The tests confirmed an ultimate tensile strength for the steel of approximately 285,000 lb/in.[2] and an impact resistance of 16 ft-lbs at both +70° and −40°F. The composition and nominal mechanical properties of the steel are given in tables 1 and 2. Even better ductility and toughness properties were obtained on a single heat that was vacuum remelted.

Preliminary experiments were carried out to determine the critical temperatures, the Ms temperature (the temperature at which martensite forms), and the maximum time that the steels could be held above the Ms temperature before transformation to other constituents occurred. Different hardening treatments using oil or air quenches were also studied. A conventional oil quench from 1,650° F, followed by double tempering in the range 400° to 500° F, produced the best all-around properties, so this heat treatment was used for all subsequent tests of the promising steels.

Although boron apparently has no particularly beneficial effect on the properties of the steels, neither does it appear to have any detrimental effect. In steel structures appreciably larger in cross section than those tested, the beneficial effect of boron in improving hardenability may be advantageous. It is believed that the properties obtained on the laboratory steels can be duplicated or even improved in well-made commercial steels.

[1] *For further technical details, see* An ultra-high-strength steel, *by Samuel J. Rosenberg and Carolyn R. Irish, Materials and Methods (May 1957).*

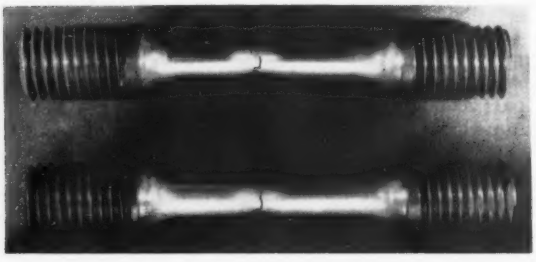
[2] Effect of boron on the hardenability of high-purity alloys and commercial steels, *by Thomas G. Digges, Carolyn R. Irish, and Nesbit L. Carwile, J. Research NBS* **41,** *545 (1948) RP1938. Also,* A study of the impact properties of boron-treated steels, *by Samuel J. Rosenberg and John D. Grimsley, J. Iron Steel Inst.* **182,** *278 (March 1956).*

TABLE 1. *Chemical composition of the NBS ultra-high-strength steels*

	%
Carbon	0.40
Manganese	.75
Silicon	1.60
Nickel	1.80
Chromium	0.85
Molybdenum	.30
Titanium	.10
Boron	.003

TABLE 2. *Mechanical properties of the NBS ultra-high-strength steels*

Hardness	Rockwell C scale	53
Ultimate tensile strength	psi	285,000
Yield strength	psi	235,000
Elongation, 1.4-in. gage-length	%	10
Reduction in area	%	35
Charpy (V-notch) impact strength:		
room temperature	ft-lbs	16
−40° F	ft-lbs	16



Tensile specimens of high-strength steel after test. The necking at the fracture of the tensile specimens indicates the steel's high ductility.

Atmospheric Radio Noise Recording Program

THE BUREAU has set up 16 radio noise recording stations throughout the world as part of the International Geophysical Year program. These stations will record radio signals generated by the more than 50,000 thunderstorms occurring daily on earth. This noise recording program, conducted by W. Q. Crichlow, R. T. Disney, and F. F. Fulton, Jr., of the NBS Boulder (Colorado) Laboratories, is expected to increase man's knowledge of radio interference and the propagation of radio waves through the atmosphere.

During the past year the atmospheric radio-noise recorder developed at NBS has been accepted internationally as appropriate for use in a worldwide measurement program. These receivers provide continuous recordings of the average power of the noise received on a standard antenna at eight discrete frequencies in the range from 15 kilocycles per second to 20 megacycles per second. In addition, some have been modified to record also the average noise voltage and the average of the logarithm of the noise voltage. It has been shown that these three statistical characteristics of the noise provide a reasonably comprehensive picture of the physical nature of its amplitude distribution.

Some manmade radio noise will also be recorded and studied. However, most of the recording sites will be as far as possible from these sources of interference. For example, one station is installed at Marie Byrd Base in the Antarctic, which is far removed from the radio noise of civilization and from the belt of high thunderstorm activity circling the equator. Information will be gathered at this base about the radio waves that travel long distances through the atmosphere.

The antarctic site is also an ideal place to study radio noise originating in the sun and the stars. Moreover, the station is inside the auroral zone—the belt around the pole where the southern lights appear during magnetic storms—and thus will provide information on the effect this zone has on radio waves passing through it.

Stations planned for operation by the Boulder Laboratories or other U. S. Agencies will include Marie Byrd Base, Antarctica; Maui, T. H., Thule, Greenland; and Balboa, Canal Zone, in addition to the stations within the continental United States. Stations which will be operated by other governments but equipped by NBS will be located at Accra, Gold Coast, Africa; Cook, Australia; Johannesburg, Union of South Africa; Rabat, Morroco; San Jose dos Campas, Brazil; Singapore, Malaya; Stockholm, Sweden; and Tokyo, Japan. India will cooperate in the network by furnishing and operating two stations.

All data from the various stations will be forwarded to the Boulder Laboratories for analysis. The results of this study will not only provide valuable information about radio propagation and meteorology but will also establish an engineering basis for assigning frequencies to stations. For the commercial and military radio users who must know which frequencies are best for use at a given time and place, forecasts will be made of the amount of unwanted noise that will interefer with their communications. With other information provided by the Bureau, they will be able to tell the minimum transmitter power that can be used to get their information to the receiver in spite of competition from noise of natural origin.

Building above is one of the worldwide chain of recording stations that will be recording radio noise generated largely by thunderstorms. The vertical rod near the center of the building is the receiving antenna and the radiating wires are used to stabilize reception.

ELECTRONIC COMPUTER STUDY OF ENGLISH SYNTAX PATTERNS

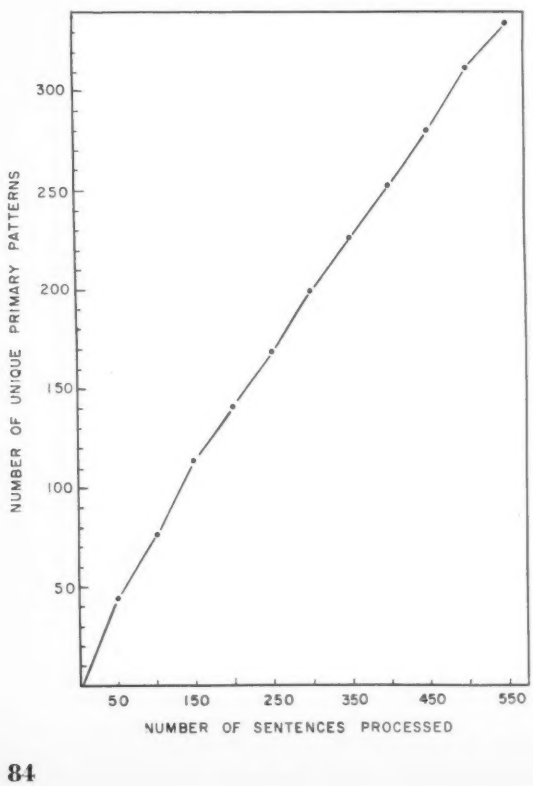
WITHIN THE SCOPE of natural English language, an infinite number of different sentence structures is possible. One might expect that some of these structures occur much more frequently than others and account for the bulk of sentences actually used. Information about such occurrences would be of interest in many fields, scientific as well as literary, and the question has therefore often been discussed. More specifically, information is needed on the statistical frequencies with which different structures are used. The complexity of this problem is such, however, that little or nothing appears to have been definitely established concerning it.

Recently the Bureau completed a brief exploratory study of the problem with the help of its automatic digital computer SEAC (Standards Electronic Automatic Computer).[1] Carried out by R. B. Thomas and P. I. Herzbrun of the NBS data processing laboratory, this study suggests, at least, that the problem is not entirely insoluble. Although only a small sample (550 sentences) was studied, some of the results are believed sufficiently interesting to justify further investigation along the same lines. The research is being supported by the U. S. Patent Office.

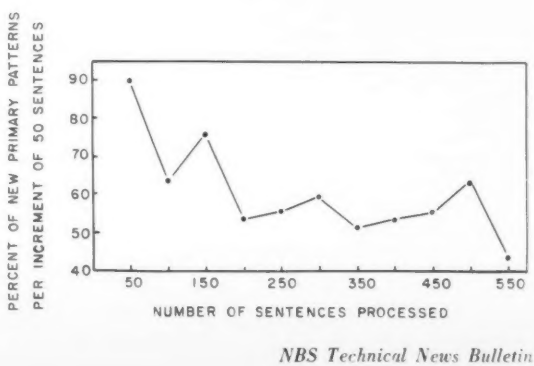
The Bureau's interest in linguistics stems from the need for better structural understanding of language in many data processing applications—in particular, the expression of information for mechanized searching of patents. In addition, structural research may ultimately yield useful techniques for machine translation of languages.

In any statistical study of syntactical forms, there are a number of difficulties that must be taken into account. One difficulty is that the same thing can be said in several ways and by means of different syntactical structures. On the other hand, the same expression may be susceptible of several different meanings and may perform different functions in the sentence. Just which interpretation is correct depends in a complicated way on the verbal context. Also dependent on complicated contextual clues are the meanings that must often be read "between the lines." Morever, to mention only one more difficulty, there are the complications introduced by words that indicate the mood or attitude of the author—approval or disapproval, doubt or assurance, enthusiasm or irony.

In the Bureau's study, the sentences analyzed were selected, with a rough attempt at randomization, from scientific sources—journal articles and books. It was hoped that this would provide a maximum of straightforward, factual statements and a minimum of ambiguity and emotional or attitudinal factors. In any



Graph at left shows the rate at which the number of primary syntactical patterns in English sentences increased with the number of sentences. A simple code was used to express sentence structure as a series of numbers, and the results were analyzed with the help of the Bureau's automatic electronic computer, SEAC. If most sentences fell into only a few forms, the graph would be expected to "saturate" (i. e., become horizontal) fairly rapidly. In the present small sample of 550 sentences, only a slight tendency in this direction seems to be evident. Graph below, based on the same data, exhibits this tendency somewhat more clearly. This shows the number of new primary syntactical patterns found in successive groups of 50 sentences examined. In view of the small size of the total sample, this result is considered quite tentative, though sufficiently interesting to justify further study along the same lines.



case, attitudinal factors were ignored. Because scientists are supposedly disciplined in the careful definition and use of terms, some surprise was occasioned by the amount of ambiguity that was found. However, though considerable effort was required at times, the ambiguities were in all cases satisfactorily resolved.

A crucial feature of such an investigation is the system of syntactical concepts to be adopted. Feasible systems of many kinds can be devised, of varying complexity. In an effort to keep the problem tractable, a simple and coherent, but relatively coarse-grained scheme was devised. This consists, first, of 6 major categories, with code numbers 1 to 6:

1------Subject
2------Object (direct or indirect)
3------Predicate nominative
4------Adjectival modifier
5------Adverbial modifier
6------Verb

Second, there are 3 coordinate categories, coded by the letters A, B, C. In connection with categories 1 to 5, A stands for a lexical unit (e. g., "neutron," "mother-in-law," "John Smith," "collides," or "worldwide"); B stands for a phrase; and C represents a dependent clause. In connection with verbs, the letters stand for main, auxiliary, and modal auxiliary, respectively. Thus 1B is the code for a subject expressed by a phrase, 4A stands for an adjectival modifier consisting of a lexical unit, and 6B stands for an auxiliary verb.

Only independent clauses were analyzed and coded in terms of their elements. Other structures were coded by one notation each (a "notation" consists of a number followed by a letter) to represent the function of the whole structure. Connectives, absolutes, appositives, and similar elements that do not affect the basic structure of the independent clause were not coded. Also ignored were elements that modify B and C elements that have already been coded.

The following sentences illustrate the coding scheme:

1A 6B 6A ┌──5B──┐
We are living in a world of expanding parameters.

1A 6A
We observe
──────2C──────
that a lion has at least the connectivity of the torus.

The phrase "of expanding parameters" was not coded because it modifies a portion of the preceding B element. Although the letters A, B, C were used in coding the sentences, no statistical use was made of them in this first phase of the Bureau's study; the letters are therefore omitted from the illustrations of coded sentences given below.

Coding of the sample sentences was done by hand: the trick of doing this with fair speed is soon acquired. Coding by machine would, of course, be preferable; but in the current state of the art machines cannot, for example, choose among the different interpretations of ambiguous expressions in a limited context. In fact, one of the ultimate aims of studies such as the present one is to make possible machine operations of this kind. SEAC, on the other hand, did perform three very valuable functions: Accurate high-speed tabulation, precise comparison of data, and compression of coded data in terms of syntactical equivalence relationships (see below).

Primary Search

In the first part of the study, the "primary" sentence patterns—the patterns comprising the sequence of code numbers—were intercompared. One hexadecimal digit (i. e., 4 binary digits) was used to express each coded element and 2 hexadecimal digit positions were reserved for counting. Because SEAC can handle numbers up to 11 hexadecimal digits in length (plus one binary digit for algebraic sign), coded patterns were limited to 9 hexadecimal digits, leaving 2 digit positions for counting. Extremely few sentences would have required more than this number of code figures, and the limitation is considered negligible.

The computer program calls for the first incoming sentence-code (containing numbers and letters) to be reduced to its numerical pattern, which is then stored. A sentence with the primary pattern, 1665, for instance, would be stored in the form 16650000000. Each subsequent pattern is reduced in the same way, and its numerical pattern is compared with all stored patterns. If a candidate pattern is identical with a stored pattern, a recurrence tally of 1 is added into the last place of the stored pattern, and the candidate pattern is rejected. Thus, when the pattern 1665 appears for the second time, the stored number becomes 16650000001. If the candidate pattern is new, it is stored along with the others. Check routines are also included to reject erroneously prepared data.

When all sentences have been processed, the resultant unique primary patterns, with their tallies, emerge from the computer via high-speed magnetic wire recording. These are accompanied by other tallies showing (a) the number of sentences processed, (b) the number of unique patterns obtained, (c) the number of sentences rejected for errors in preparation, and (d) the number of patterns having 1 digit, 2 digits, . . ., 9 digits. After each group of 50 sentences, SEAC prints out the total number of sentences processed and the number of unique patterns held in storage.

Among the 550 sentences thus far studied, 335 unique primary patterns were found. When the number of unique patterns is plotted against the number examined, the graph shows little tendency to reach zero slope. The rate of occurrence of new patterns within each increment of 50 barely suggests a falling off in the number of new patterns.

The maximum recurrence of any primary pattern was 12, for each of two patterns: 41665 (e. g., "The dog has run across the street") and 414665 ("The dog with floppy ears has run across the street"). The next most common pattern showed 11 recurrences—16434 ("This is a dog with floppy ears"); and the next showed 10 recurrences—162 ("Dogs eat bones"). Thus the most common primary pattern represented only 2.2 percent of the whole sample and the rest

of the patterns showed a roughly even distribution of nonsignificant recurrence.

Compressed Search

A study was also made of the effect of "compressing" the primary patterns. For example, when the subject of the sentence is preceded by two or more successive adjectival expressions, the latter would be considered as a single adjective. Thus, "The little red hen clucks" (44416) was considered syntactically equivalent to "The hen clucks" (416). Similarly, a string of verbs is compressed into a single verb. The same syntactical form would therefore be assigned to "The hen will cluck" (4166) as to "The hen clucks" (416). In general, then, the computer program for the "compressed" search rejects all but one of any digit that is contiguously repeated within a pattern; so that 44416665500 becomes 41650000000, but 41465600000 is unchanged.

A 1 was added to the tally of each primary pattern before compression, to show the actual number of occurrences in each case. The compressed patterns are then compared, each with all the others—because a number of patterns whose primary forms were different would probably be identical in their compressed forms. When SEAC finds that two compressed patterns are identical, their respective tallies (carried over from the primary comparison) are added together. The sum is stored in the least-significant places of the first pattern in question and the other pattern is cleared to zeros. At the end of the comparison the unique compressed patterns, with their tallies, are printed out on wire, together with (a) the number of compressed patterns remaining as unique and (b) the number of unique compressed patterns with a given number of digits (1 to 9).

TABLE 1. *Five most common compressed patterns, with examples illustrating each structure and approximate distribution in percentage of patterns compared*

Percent	Pattern	Example
12.5	4165	The dog ran across the street.
9.2	41465	The dog with floppy ears ran across the street.
8.0	165	He ran across the street.
5.5	416424	The dog ate the bone which he had dug up.
5.0	162	Dogs eat bones.

The compressed patterns showed the expected higher degree of identity. There were only 189 unique compressed patterns, as against the 335 primary patterns in the sample. The five most common compressed patterns are listed in table 1, with the approximate percentage of the sample having each structure and with illustrative sentences. The first three of these patterns show that about 30 percent of the sample comprised sentences built around verbs that lack objects but have adverbial modifiers. With the aid of supplementary routines in the program, it was possible to plot the distribution of patterns (all primary, unique primary, all compressed, and unique compressed) with respect to the number of notations per pattern. In each case a very rough approximation to normal Gaussian distribution was found.

In the hope of obtaining data of greater statistical significance, further searches will be conducted on a much larger body of source sentences. The first reduction of data to numerical terms only (at the start of the primary search) and the second reduction by omission of repeated digits (i. e., the compression) seem to be useful techniques for examining structure. Both reductions are accomplished in terms of logical equivalence, and so do not affect the validity of the search within the framework of the present coding scheme. This method of examination may shed some light on the problem of structural transformations in English. An understanding of this problem is needed, for example, in developing means of "translating from English into English"—that is, from ordinary English into a form better adapted for use as a computer input or, perhaps, as a preliminary step to translation into another language.

The electronic computer proved admirably suited to this type of search. To duplicate the work on other types of equipment would require considerably more time and more complicated operations, especially in the comparison and compression phases. The actual computer time consumed, from primary pattern formation through the compression and comparisons to the final data output stage, was about 30 minutes for the whole group of sentences examined.

[1] *Further technical details are given in* The use of SEAC in syntactic analysis, *by R. B. Thomas, which will be published in Monograph Series in Linguistics and Language Studies, No. 10, Georgetown University Press, scheduled to appear November 1957.*

HYDRAULIC RESEARCH IN THE UNITED STATES

The Bureau has recently published a summary of hydraulic research in the United States and Canada, compiled from reports by various hydraulic and hydrologic laboratories. The projects are listed chronologically with the assigned numbers repeated for identification purposes until a project is completed. Projects numbered from 2255 on are reported for the first time and all projects are in an active state unless otherwise noted.

File reports or other detailed information are not included in the volume but may be obtained from the correspondent listed under or immediately following the title of the organization reporting the work.

This publication, entitled Hydraulic Research in the United States, National Bureau of Standards Miscellaneous Publication 218, by Helen Middleton, 216 pages, $1.50, is available from the Government Printing Office, Washington 25, D. C.

Powders for Low-Temperature Insulation

THE CRYOGENIC ENGINEERING LABORATORY of the Bureau's Boulder (Colo.) Laboratories, has undertaken to improve the Dewar vessel with the aim of developing methods that are adaptable to large-scale equipment. This project is one aspect of a broad program devoted to developing and improving cryogenic techniques and obtaining engineering data.

One of the most important problems in low-temperature technology is that of keeping heat out of low-temperature equipment. The problem of thermal isolation from the external surroundings was largely solved by Sir James Dewar, who contributed one of the most important inventions to cryogenic technique—the vacuum-jacketed container, with walls of high reflectivity for rejecting thermal radiation.

The best of Dewars—as these containers are called—has a heat leakage by radiation across its vacuum jacket of the order of 1 milliwatt/cm² between walls with temperatures of 300° and 76°K. The leakage by thermal radiation between walls at 76°K and 20° or 4°K in the same vacuum-walled flask is of the order of 2 microwatts/cm² for the very best flasks, and usually runs from 10 to 20 microwatts/cm². If the gas pressure is allowed to increase, all the above "heat leaks" are increased correspondingly.

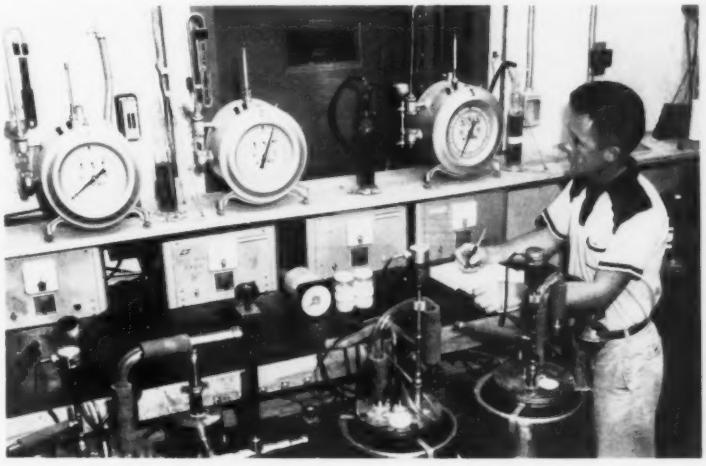
For large-scale apparatus, investigation has indicated that evacuated powders such as perlite, diamataceous earth, and silica aerogel provide a decided improvement over the standard vacuum-walled low-emissivity Dewar vessel. In addition, the evacuated-powder insulated vessel can have high-emissivity walls and a thousand times greater gas pressure without destroying its usefulness as an efficient low-temperature vessel.

A study of powder insulation has been undertaken by M. M. Fulk, R. J. Devereaux, and J. S. Schrodt of the Bureau's Cryogenic Engineering Laboratory to obtain additional data on powders already in use and to determine the properties of powders and mixtures of powders that have not previously been investigated.

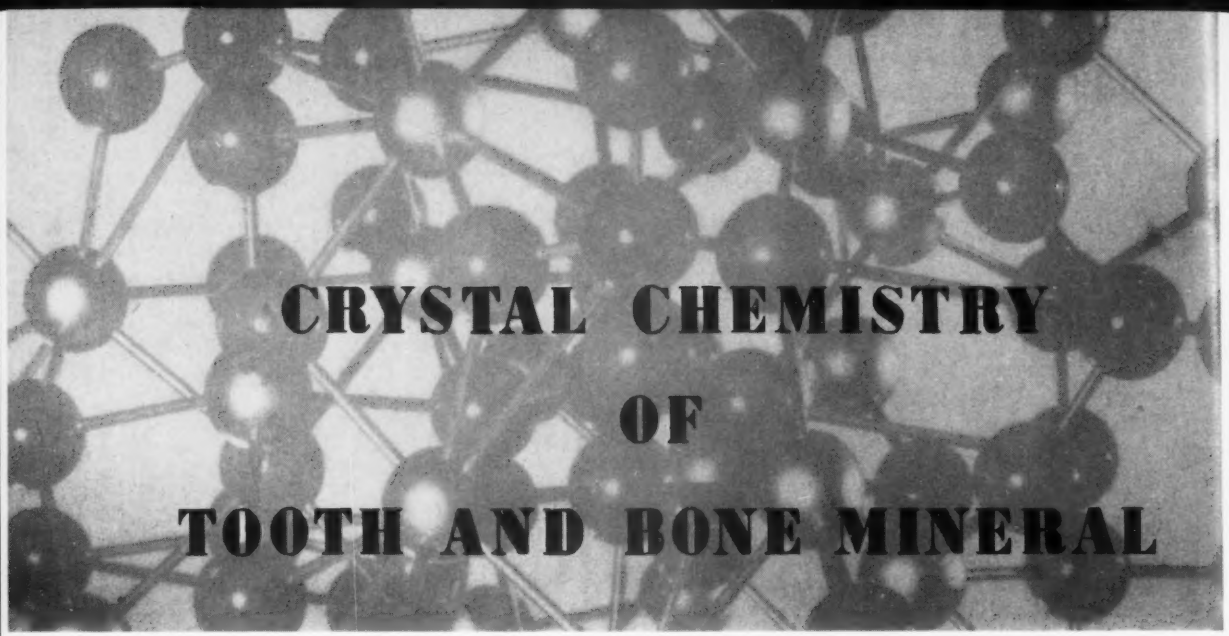
Reduction of the over-all heat leak through powders can be achieved in a number of different ways that may be used either separately or in combination. The total heat transport is lowered by pumping out the gases, by increasing the degree of subdivision, by increasing or decreasing the density of the powders, by adding metallic powders to make the material "opaque" to thermal radiation, by disrupting or minimizing the amount of crystal structure, and possibly by other methods that remain to be explored.

By using the methods now available, one can make the over-all thermal resistance of a vessel with a 2- to 3-cm thickness of some evacuated powders as good as or better than a "high-vacuum" jacketed vessel in the interval of 300° to 76°K.

At present, single-component evacuated powders find their principal commercial application in vessels for large-scale storage and transportation of liquid oxygen. A further step has been the construction of a powder-insulated vessel for truck transportation and short-time storage of liquid hydrogen, the first large-scale liquid hydrogen vessel that does not require use of a thermal shield cooled by an auxiliary refrigerant such as liquid nitrogen. The superior performance of the metal powder mixtures permits extensions of these applications and should encourage the use of this insulating principle in other applications requiring efficient insulation. Possible fields of application are gas liquefaction and rectification and low-temperature chemical processes.



Experimental setup used to measure heat transport through powders. The heat leak is used, in turn, to calculate the apparent mean thermal conductivity for various boundary conditions and powder compositions. These experiments performed at the NBS Cryogenic Engineering Laboratory at Boulder, Colorado, are part of a program to develop improved insulation for low-temperature equipment. The techniques are intended for large-scale applications such as the commercial storage and transportation of liquid hydrogen.



CRYSTAL CHEMISTRY OF TOOTH AND BONE MINERAL

USING THE TECHINQUES of chemical crystallography, scientists at the National Bureau of Standards are developing new information on the nature of calcified tissue. The Bureau's dental research laboratory has synthesized pure single crystals of hydroxyapatite [1]—the prototype of the main mineral constituent in teeth and bone. Both the synthetic and naturally ocurring apatites have been analyzed by X-ray diffraction and infrared absorption spectroscopy.[2] Results of the study may lead to a better understanding of the function of calcified tissue in the body and eventually perhaps to new methods of treating diseased teeth and bone.

The current investigations are being conducted by A. S. Posner, Research Associate, American Dental Association, A. F. Diorio, a guest worker from the Walter Reed Army Medical Center, and A. Perloff of the Bureau staff. The NBS constitution and microstructure laboratory is assisting in the work, and the National Institutes of Health and the Army Medical Center have cooperated on specific projects.

Apatite Minerals

The apatites are the most abundant of the phosphate minerals. The name "apatite" was derived from the Greek word meaning "to deceive" because the mineral was often confused with others like acquamarine or amethyst. Pure hydroxyapatite is a chemical rarity having the formula $Ca_{10}(PO_4)_6(OH)_2$. However, the mineral known as hydroxyapatite always contains a certain portion of fluoride ions (F^-) replacing the hydroxyl ions (OH^-).

Previous analyses had shown that tooth mineral is some form of hydroyapatite mixed with other phases. Thus the study of the calcified tissue in teeth ties in with that of the apatite family of minerals. Besides providing a better understanding of the structure and function of dental enamel, the data developed should be useful in a number of other fields including mineralogy, crystallography, basic chemistry, and physics.

The crystallographic studies at the Bureau indicate that the major constituent of tooth mineral may be a calcium-deficient hydroxyapatite.[3] Chemical analyses of sound human teeth show they contain less than 10 calcium atoms for every 6 atoms of phosphorus. In other words, there is not enough calcium to provide the 10Ca/6P ratio found in perfect hydroxyapatite. However, X-ray and index of refraction studies of teeth definitely indicate the presence of apatite. The evidence taken together suggests the presence in teeth of defect apatites in which some of the calcium ions are missing from certain structural positions and electrical neutrality is achieved by the inclusion of hydrogen ions in the proper amount somewhere in the structure. This concept may lead to an explanation for the differences in reactivity (i. e., solubility, hardness, caries resistance, etc.) of one tooth as compared to another.

Synthesis of Pure Hydroxyapatite

In order to obtain basic information on the purer forms of the apatite minerals, a standard pure apatite was synthesized at the Bureau in a hydrothermal bomb. The crystals were examined by X-ray diffraction, infrared spectroscopy, and other techniques. The synthesis procedure involves hydrolyzing monetite ($CaHPO_4$) to hydroxyapatite in a closed system. The materials—0.1 g of monetite and 10 ml of water—were placed in a platinum-lined hydrothermal bomb and subjected to a temperature of 300° C for 10 days. During this time the system had an internal pressure of about 1,250 psi due to the vapor pressure of the saturated steam. Crystals were formed ranging up to 0.3

mm in length with negligible quantities of impurities. It should eventually be possible to produce even larger crystals which can be used as standard reference samples in X-ray diffraction studies of all apatite minerals.

Defect Apatites

By controlling the *p*H at which the apatite is precipitated it is possible to produce calcium-deficient or "defect" hydroxyapatite. A number of compounds of this sort were produced ranging from the calcium-phosphorus ratio of pure hydroxyapatite (10Ca/6P) to a low Ca/P ratio of 8.2/6.0. In general the Ca/P ratio of apatitic calcified tissue (bone, teeth, etc.) lies below the value expected of pure hydroxyapatite.

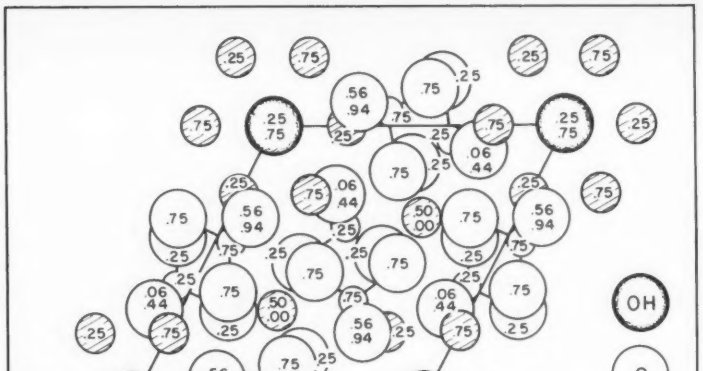
Because a structure from which cations are removed has an excess of negative charges, it was postulated that the proper number of hydrogen ions enter the hydroxyapatite structure, not directly in calcium positions, but as hydrogen bonds between orthophosphate oxygens. Recent infrared absorption studies show that pure hydroxyapatite does not contain such hydrogen bonding whereas synthetic defect apatites and calcified tissue do.

Some of the chemical properties of these defect apatites are different from those of pure hydroxyapatite. An example directly applicable to biochemistry is the solubility. The Bureau in cooperation with NIH has demonstrated that when the synthetic low-calcium apatites react with calcium acetate, the solubility in weak lactic acid is reduced by about 35 percent.[4] Studies with rat molar teeth yielded similar results. This may provide a mechanism whereby chemical treatment may produce a more stable tooth structure.

Carbonate

The carbonate found in tooth and bone mineral is of the order of 3 percent carbon dioxide by weight, but its function in calcified tissue remains uncertain. Also, its exact crystallographic placement in the tooth structure has been debated. For example, is the carbonate substituted in the apatite crystal, or admixed or adsorbed as a separate phase. In order to investigate this problem, a number of techniques were employed at the Bureau, including X-ray diffraction, infrared absorption spectroscopy, electron microscopy, and preferential solubility studies. It was concluded that carbonate occurs as admixed or adsorbed calcite

Checking alinement of single crystal X-ray camera for apatite crystal studies. The tiny crystal approximately 0.3 mm long is carefully placed in the center of a thin, monochromatic X-ray beam which emanates from the X-ray tube through a pinhole collimater. The X-ray exposure is recorded on film in a cylindrical camera (not shown) which is placed around the crystal. Equipment (right) is an X-ray goniometer for powder diffraction studies.



Projection of the unit cell of fluoroapatite on the basal plane. The numbers indicate the relative distances of the various ions above the base. In hydroxyapatite, hydroxyl ions (OH^-) are in the places shown for the fluoride ion.

($CaCO_3$) or magnesite ($MgCO_3$). As the particles are not detected by X-ray diffraction or electron microscopy, it is suggested that the carbonate particles are two small to be seen by these techniques.

Small Particle Size

Small crystal size is a striking feature of the chemically precipitated basic calcium phosphates, precipitation being the mechanism by which bone is produced in the blood serum. Dentin and enamel mineral and synthetically precipitated apatites have average crystal diameters in the range below 1000 A and may be studied by the line broadening methods of X-ray diffraction.

These studies indicate an average crystalline diameter ranging from 150 to 300 A for bone, dentin, and the precipitated apatites. Particle size distribution curves obtained from line broadening experiments show that steam-autoclaved bone contains crystals ranging from 50 to 1000 A in diameter with about 80 percent appearing in the 300 A region.

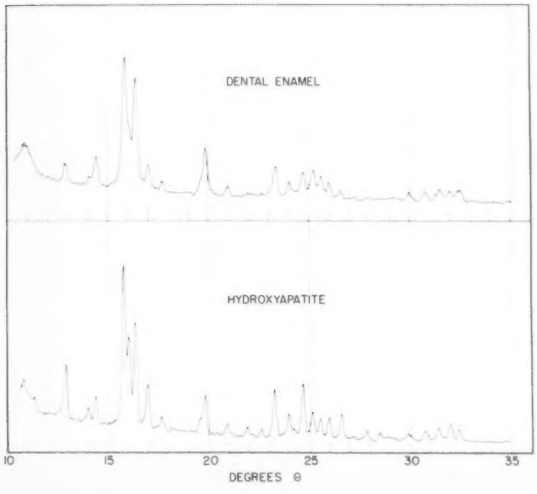
These measurements are biologically significant because they confirm the large specific surface apparent in the apatite of calcified tissue and underline the importance of surface reactions in the functioning of bone and teeth. If indeed the apatite in teeth and bone are defect apatites, the properties of the biological apatites will change with increasing exposure to ions that can fill the defects. Cooperative studies between NIH and NBS are in progress on the application of the defect apatite theory to explain aging in bone and teeth mineral and the general function of apatite in these systems.

[1] *For further technical details, see* Preparation of pure hydroxyapatite crystals, *by A. Perloff and A. S. Posner, Science* **124,** *383 (1956).*

[2] *A. S. Posner and G. Duyckaerts,* Infrared study of the carbonate in bone, teeth, and francolite, *Experientia* **10,** *424 (1954).*

[3] *A. S. Posner and A. Perloff,* Apatites deficient in divalent cations, *J. Research NBS* **58,** *279 (1957) RP 2761.*

[4] *R. C. Likins, A. S. Posner, and A. C. Steere,* Effect of calcium treatment on solubility and calcium uptake of synthetic hydroxyapatite and rat molar enamel. *Presented at meeting of International Assoc. for Dental Research, Atlantic City, N. J. (March 1957).*



Comparison of X-ray diffraction powder patterns of tooth enamel and synthetic hydroxyapatite. The enamel was treated at NBS in a hydrothermal bomb to enlarge the average crystal size.

High-Frequency Magnetic Measurements

AN rf permeameter, incorporating recent improvements and modifications,[1] has been found to give increased accuracy and versatility in the measurement of commercially available magnetic materials. The utility of the instrument has been demonstrated at the NBS Boulder Laboratories in work carried on under A. L. Rasmussen. Highly accurate measurements have been made of temperature dependence of initial complex permeability and of d-c biasing field dependence of parallel reversible permeability.

An impedance transformer, the rf permeameter has a wound, powdered-iron, toroidal core as a primary and a shorting enclosure which envelopes both the primary and a toroidal test sample core as a secondary. Removable primaries, provided with connectors for terminals at one end of the enclosure, have different input impedances for the frequency range from 20 kc or lower to 50 Mc or higher. The test core is inserted at a removable shorting end of the enclosure or section of coaxial line, where it is surrounded by a nearly uniform sheet of current. Relatively small impedance changes in the secondary are easy to detect at the input to the primary. Because the form of the test core is toroidal, corrections for end effects are not necessary.

Permeameter cavities have been constructed to accommodate toroidal samples in the following range: Outside diameter 1 to 1.6 in., inside diameter $\frac{1}{8}$ to $\frac{1}{2}$ in., heights to approximately 1 in.

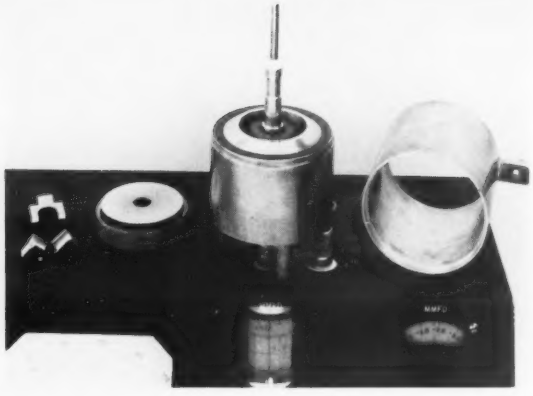
In making measurements, the primary of the permeameter is placed in one arm of an rf impedance bridge or across the terminals of a Q meter. Input impedances of the primary are then measured with (1) permeameter secondary open, (2) permeameter secondary shorted without sample, and (3) permeameter secondary shorted with a sample enclosed. From these data, initial permeability (μ') and dissipation factor [$\tan \delta_m = (\mu''/\mu')$] are derived. Equations for permeability and dissipation factor have been developed to cover the frequency range 20 kc to 50 Mc and to include low-loss and high-loss materials. Dissipation factors can be measured with an accuracy of ± 10 percent or ± 0.006 (whichever is the larger) over the range of 100 kc to 35 Mc with a Q meter calibrated for capacitor increments as the measuring device.

The permeameter may be calibrated by reference to a set of standard toroids made from relatively stable powdered iron which have little change in real permeability with frequency and relatively low losses. An accuracy of the order of 1 percent was obtained by using standard toroids measured for this purpose on the standard rf permeameter. This primary standard is a variable-length coaxial line, with input connected to a radiofrequency bridge.[2] Permeability of an electrically thin sample is determined from the change in length of the line, which is equivalent to the inductance change introduced by the sample placed at the end of the line.

Permeameter is shown nearly assembled. After the d-c outer conductor is placed in position, a wire is connected to the d-c inner conductor (projecting central rod) to complete the d-c current path.

For temperature dependance measurements the permeameter has a toroidally shaped oven of copper in the secondary (surrounded by glass-fiber insulation) and a water coolant circulating in the permeameter walls. The oven has a toroidal sample space of the following dimensions: Outside diameter of 1.15 in., inside diameter of 0.5 in., and height of 0.25 in. The toroid is enclosed in the oven by means of a two-piece copper cap. A narrow circumferential slit between the two copper pieces is necessary in order to avoid shielding the magnetic material from the rf field and still maintain a sufficiently uniform temperature in the sample.

Measurements have demonstrated that a toroid, heated relatively slowly, approximates the oven wall temperature and has a nearly uniform temperature distribution when noninductively wound Nichrome heater wires encased in copper at the under side are energized. Water circulating in the walls of the permeameter maintains the body of the permeameter at an almost constant temperature while the oven is in operation.



Permeameter is shown on a *Q* meter with a toroidally shaped ferromagnetic material inserted in the open secondary. The center and outer conductors (center rod and outer case of the permeameter, respectively) form the d-c coaxial line that is electrically insulated from the body of the permeameter. The secondary of the permeameter is shorted with the shorting place and three-piece clamp assemblies shown on the left. The primary input terminals protrude through holes in the shorted end of the d-c line. The cylinder seen on the right adds height to the outer conductor of the d-c path.

The temperature range of the oven is from room temperature to greater than 275° C (527° F). A copper-constantan thermocouple junction located in a corner of the oven aids in determining temperature.

The effect of any small magnetic field from the Nichrome heater wires was negligible on a ferrite test core with a coercive force of 0.08 oersted. Other ferrites with possibly lower coercive forces appeared also unaffected.

The accuracy and precision of temperature dependence measurements are approximately the same as those made with the rf permeameter, whereas measurements of complex permeability changes are about as precise as the maximum *Q* as read from the *Q* meter or the null determined from a bridge.

To make parallel reversible permeability measurements on rf magnetic materials, a relatively large rf permeameter was modified to provide a d-c biasing field which is parallel to and concentric with the rf field inside the permeameter secondary. This was done by incorporating the permeameter symmetrically within a shorted section of coaxial line. The center conductor protrudes through a hole in the center of the permeameter and is separated from the permeameter by an electrical insulator. The open end of the d-c coaxial line extends approximately one outer diameter above the permeameter secondary so that the parallel field is distorted negligibly. To this line d-c currents in either direction as high as 60 amp may be applied. At 60 amp, the magnetic field, 1 cm from the center of the permeameter, is approximately 12 oersteds. An rf choke in the d-c circuit prevents rf currents of significant values from appearing in the line.

The accuracy and precision of measurements of reversible permeability as a function of field dependence are approximately the same as those made with the rf permeameter. However, results obviously depend upon the accuracy with which the d-c biasing field is determined, especially for those materials that change rapidly as a function of d-c field and upon the concentricity of the test torroid relative to the center conductor. In this instrument also, measurements of complex permeability changes are about as precise as the maximum *Q* as read from the *Q* meter or the null determined from a bridge.

Also of interest is reversible permeability as a function of a d-c biasing field perpendicular to the applied rf field. Instrumentation to measure this is under consideration.

[1] *For further technical details, see* Advances in the design and application of the radiofrequency pereameter, *by A. L. Rasmussen, A. W. Enfield, and Alfred Hess, J. Research NBS* **56**, *261 (1956) RP2673, also* A radiofrequency permeameter, *by Peter H. Haas, J. Research NBS* **51**, *221 (1953) RP2454.*

[2] High frequency calibration of magnetic materials, *NBS Tech. News Bul.* **36**, *158 (Oct. 1952).*

Addendum to Radiation Handbook 60

IN A RECENT STATEMENT,[1] the National Committee on Radiation Protection and Measurements (NCRP) presented in brief form its new recommendations on maximum permissible radiation levels, a revision of those contained in National Bureau of Standards Handbook 59, *Permissible Dose from External Sources of Ionizing Radiation*. The introduction of these new working levels makes necessary the revision of some of the Committee's other recommendations, which are also published in the NBS Handbook Series. These deal with various phases of radiation protection such as monitoring methods, waste disposal, safe handling of isotopes, and radiation legislation.

Until detailed revisions can be completed, corrective statements are being prepared for each of the handbooks, indicating the changes needed to comply with the new maximum permissible levels. The first such statement, for Handbook 60, *X-ray Protection*, has been completed. Holders of Handbook 60 may obtain copies of this addendum on request to the National Bureau of Standards, Editorial and Printing Section, Washington 25, D. C.

[1] Maximum permissible radiation exposures to man, *a preliminary statement of the NCRP, NBS Tech. News Bul.* **41**, 17 *(Feb. 1957). Copies of the preliminary statement, for insertion in Handbook 59, are available to holders of that Handbook on request to the National Bureau of Standards, Editorial and Printing Section, Washington 25, D. C.*

A SIMPLE TRANSISTOR BETA TESTER

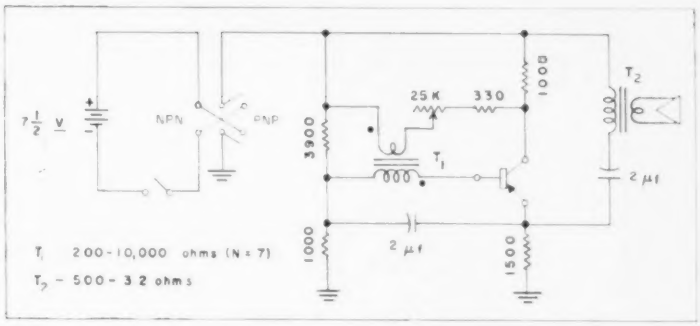
for rapid determination of transistor gain

A simple, inexpensive laboratory instrument for measuring the current gain or β, of a wide variety of transistors has been developed by the Bureau. The testing device, designed by G. F. Montgomery of the Bureau's electronic instrumentation laboratory, measures the common-emitter short-circuit current gain of *pnp* or *npn* transistors at low audiofrequency.

In operation, the transistor is plugged into the instrument, and a dial is adjusted to the point where a tone is heard from a loudspeaker. The β is then read directly from the dial. Properly calibrated, the instrument can measure β accurately from 10 to 170.

The circuit is similar in principle to one used for measuring vacuum tube transconductance. In such a tube circuit, part of the plate voltage is fed back into the grid through resistor and transformer coupling to cause oscillation. Similarly, with the circuit for measuring transistor gain, the output is fed back into the input through a variable resistor and a transformer; when the resistor is properly adjusted, the circuit begins to oscillate at an audiofrequency. The dial on the variable resistor can be calibrated through a substitution method.

To reduce the number of controls to a minimum, circuit parameters are chosen so that the transistor will adjust itself to a specified d-c operating point. The resistors in the circuit were selected to fix this point at about 5 v collector potential and 1 ma collector current. For any transistor whose β falls within the measuring range of the instrument, these d-c values will be closely approximated when the transistor is plugged in.



Circuit diagram of transistor β tester. When 25K pot is properly adjusted for a given transistor, circuit oscillates at an audiofrequency and tone can be heard from loudspeaker.

The frequency at which oscillations begin depends upon the characteristics of the transformer and the phase shift of β. The current ratio of the usual audio-transformer has a broad maximum centered at 1 or 2 kc, and if the phase shift of the transistor is sufficiently small, oscillation begins at a frequency near this maximum. However, the transistor gain required to produce oscillation for a given dial setting is not a particularly sensitive function of frequency. Thus, measurements accurate to within a few percent of full scale can be expected.

Distribution of Certain Short-Lived Radioisotope Standards

Effective May 6, 1957, the Bureau will discontinue the distribution of the following radioactivity standard samples of short-lived radioisotopes which are now commercially available:

NBS Standard Sample No. 4916 Phosphorus-32
NBS Standard Sample No. 4917 Iodine-131
NBS Standard Sample No. 4918 Gold-198
NBS Standard Sample No. 4923 Sodium-24
NBS Standard Sample No. 4933 Potassium-42

Standardized samples of these nuclides may be obtained from the Nuclear-Chicago Corp., 223 West Erie Street, Chicago 10, Ill. The standards to be issued by this firm will be derived from comparisons made with the primary standards of the National Bureau of Stand ards. The firm, however, has accepted full responsibility for the standardization of the samples that it distributes.

Discontinuance of this activity will permit the Bureau to devote more of its resources toward meeting the demands of science and industry for new and more accurate standards. The Bureau's action also conforms with the Federal Government's general policy of withdrawing from activities that can be carried on by private business. The Bureau will, however, continue to maintain the primary disintegration-rate standards of these nuclides, with which commercially available secondary standards may be compared. It is anticipated that there will be no interruption in the distribution schedules of the above standards.

Handbook of Mathematical Tables

THE BUREAU has begun preparation of a comprehensive *Handbook of Mathematical Tables*. In addition to the elementary functions, the *Handbook* will cover almost the entire field of transcendental functions. Expected to be ready before the end of 1958, it will appear as a volume of about 1,000 pages—750 pages of tables, 50 pages of graphs, and 200 pages of text.

The project is supported by the National Science Foundation, and is being carried out by the Bureau's computation laboratory and numerical analysis group. Correspondence regarding the *Handbook* should be addressed to Dr. M. Abramowitz, National Bureau of Standards, Washington 25, D. C.

Numerical tables of mathematical functions are in continual demand by scientists and engineers, as shown by the success of such works as Jahnke and Emde's *Tables of Functions with Formulae and Graphs* (4th ed., New York, 1945). A greater variety of functions and higher accuracy of tabulation are now required as a result of scientific advances and, especially, of the increasing use of automatic computers. In the latter connection, the tables serve mainly for preliminary surveys of problems before programing for machine operation. For those without easy access to machines, such tables are, of course, indispensable. The new one-volume *Handbook* will not only meet these needs, but will in many cases acquaint its users with new functions.

The need for such a handbook was originally discussed at the Conference on Mathematical Tables held at Cambridge, Mass., in 1954, under the auspices of the Massachusetts Institute of Technology and the National Science Foundation. The present project is a result of the recommendation of the Conference that the National Science Foundation support the preparation of a handbook by the National Bureau of Standards. The contents of the volume are being determined with the assistance of a Committee on Revision of Mathematical Tables appointed by the National Research Council.[1]

The primary aim is to include a maximum of useful information within the limits of a moderately large volume, with particular attention to the needs of scientists in all fields. Thus it is planned to include all Bessel functions that have found significant use in mathematical physics. This does not mean that functions are to be tabulated merely for the sake of making available as many functions as possible. If a certain function can be obtained by a single arithmetical operation (multiplication by a constant, for example) from a tabulated function, it will not be given.

In general, tabular entries will be given to a fixed number of decimal places or significant figures. In particular, the elementary functions will be tabulated to 10, 15, or more places, because of their basic importance and the essential part they play in evaluating higher functions with the aid of auxiliary functions. Mathematical constants will be given to 25 places. So far as possible, the tables will be linearly interpolable to 5 places; and in most cases no more than quadratic interpolation should be required for full accuracy.

The ordering of the contents will be essentially that in the *Index of Mathematical Tables* by Fletcher, Miller, and Rosenhead (London, 1946). Present plans call for chapters on the following topics: Powers, roots and related functions; binomial coefficients, Bernoulli numbers; fundamental constants (mathematical and physical); circular and hyperbolic functions; exponentials and logarithms; circular, exponential, and logarithmic integrals; gamma and related functions; error function, Fresnel integrals; Legendre functions; Bessel functions; elliptic functions and integrals (with a section on methods of computing elliptic integrals of the third kind); Mathieu and spheroidal wave functions; parabolic cylinder functions; hypergeometric functions (methods of computation); confluent hypergeometric functions; miscellaneous functions; orthogonal polynomials; statistical tables; interpolation coefficients, quadrature; conversion tables; combinatorial analysis; polynomial and rational approximations.

Accompanying the tables in each chapter will be a list of the most important indefinite and definite integrals, infinite series, and inequalities relevant to the tables; and in each case a bibliography will also be provided. The aim is to include only those formulas that are pertinent to computation or that exhibit important properties of the function. Asymptotic forms will be given in addition to rational approximations. The text at the beginning of each chapter will also emphasize interrelations between the various functions, calling attention to such identities as:

$$Q_0(x) = \text{arc tanh } x = \tfrac{1}{2} \log \frac{1+x}{1-x}.$$

This should enhance the usefulness of the volume while eliminating duplication. An index will list function symbols and will cross-reference a function with its functional identities.

Auxiliary functions will be used to emphasize the analytic behavior of the function and to permit tabulation over the entire range of the argument. Moreover, varying intervals will be used in order to make the table interpolable and to enable the user to compute functional values over the whole range of the argument.

Graphs are to be provided for some of the more sophisticated functions, such as the associated Legendre functions, $P_n^m(x)$. In addition to the graph, a method for obtaining the function will be given. Key values will supplement the graphs and auxiliary functions. Wherever possible, the key values will be given to an accuracy of 10 significant figures.

[1] *The committee consists of P. M. Morse, Chairman, and A. Erdélyi, M. C. Gray, N. Metropolis, R. D. Richtmyer, J. B. Rosser, H. C. Thacher, Jr., J. Todd, C. B. Tompkins, and J. W. Tukey.*

NEW RADIATION HANDBOOK

Report of the International Commission on Radiological Units and Measurements

The 1956 recommendations of the International Commission on Radiological Units and Measurements (ICRU) have been published as NBS Handbook 62. This report covers the recommendations of the ICRU as agreed upon at its meetings in Geneva in April 1956,[1] and replaces its earlier report issued in 1953.[2] The new report includes an extensive amount of basic information and data necessary to make radiation dose measurements in energy units (rads), and to convert data expressed in roentgens to the equivalent in energy units.

The first of the four chapters into which the Handbook is divided contains a comprehensive discussion of radiological quantities, units, and symbols. This includes some pertinent considerations with regard to the parameters involved in the various definitions. In chapter II, guidance is provided for the clinical application of absorbed dose measurements, and examples show how the measurements may be used in practical applications. Chapter III presents a detailed treatment of the physical aspects of absorbed dose determination. This covers methods of calculating absorbed dose from measured ionization; the necessary physical data are provided in the form of curves or tables. There is also a discussion of the problem of dosimetry accuracy in X- and gamma-ray therapy.

Reports of the subcommittees are given in the final chapter. The results of several recent international comparisons relating to both X-rays and radioactivity are described. Chapter IV also includes lists of the primary standards, X-ray standards, and radioactivity standards available in various countries and laboratories, as well as an extensive bibliography covering much of the subject matter contained in the report. A suggested outline of an international treatment summary form is given in one of the appendixes.

Copies of this publication may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at a cost of 40 cents each. It is anticipated that translations of the report will be made into other languages.

[1] *See* Meetings on radiation units and protection. *NBS Tech. News Bul.* **40,** *102 (July 1956).*

[2] Recommendations of the International Commission on Radiological Units. *Am. J. Roentgenology, Radium Therapy, and Nuclear Medicine* **71,** *139 (Jan. 1954).*

Publications of the National Bureau of Standards

Journal of Research of the National Bureau of Standards, Volume **58,** No. 5, May 1957 (RP2755 to RP2761 incl.), 60 cents. Annual subscription $4.00.

Technical News Bulletin, Volume **41,** No. 5, May 1957. 10 cents. Annual subscription $1.00.

Basic Radio Propagation Predictions for August 1957. Three months in advance. CRPL–D 153. Issued May 1957. 10 cents. Annual subscription $1.00.

Research Papers

Journal of Research, Volume **58,** No. 5, May 1957. 60 cents.

RP2755. Frequency conversion with nonlinear reactance. Chester H. Page.

RP2756. Amplitude and phase of the low-frequency ground wave near a coastline. James R. Wait.

RP2757. Vessels for the storage and transport of liquid hydrogen. B. W. Birmingham, E. H. Brown, C. R. Class, and A. F. Schmidt.

RP2758. Infrared spectra of polychlorobenzenes. Earle K. Plyler, Harry C. Allen, Jr., and E. D. Tidwell.

RP2759. Infrared spectra of chromatographically fractionated asphalts. James E. Stewart.

RP2760. Thermal conductivity of nitrogen from 50° to 500° C and 1 to 100 atmospheres. R. L. Nuttall and D. C. Ginnings.

RP2761. Apatites deficient in divalent cations. Aaron S. Posner and Alvin Perloff.

Miscellaneous Publications

M219. Report of the Forty-First National Conference on Weights and Measures, 1956. 70 cents.

Handbooks

H62. Report of the International Commission on Radiological Units and Measurements (ICRU) 1956. 40 cents.

Publications in Other Journals

Confidence intervals for a proportion. Edwin L. Crow. Biometrika. (Secy., Biometrika Office, Dept. of Statistics, Univ. College, London WC1, Eng.) **43,** Parts 3 and 5, 423–435 (Dec. 1956).

Dynamic and static tests for mechanical properties of fired plastic refractories and other more resilient materials. L. E. Mong and W. L. Pendergast. J. Am. Ceram. Soc. (2525 N. High Street, Columbus 2, Ohio) **39,** No. 9, 301–308 (Sept. 1956).

Electrodeposition of metals from organic solutions. III. Preparation and electrolysis of titanium and zirconium compounds in nonaqueous media. W. E. Reid, Jr., J. M. Bish, and Abner Brenner. J. Electrochem. Soc. (Mt. Royal and Guilford Aves., Baltimore 2, Md.) **104,** No. 1, 21–29 (Jan. 1957).

Mass spectrometry. Vernon H. Dibeler. Anal. Chem. (American Chemical Society, 1155 16th St., N. W., Washington 6, D. C.) **28,** No. 4, 610–615 (Apr. 1956).

Slit function effects in the direct measurement of absorption line half-widths and intensities. Henry J. Kostkowski and Arnold M. Bass. J. Opt. Soc. Amer. (American Institute of Physics, 57 E. 55th St., New York 22, N. Y.) **46,** No. 12, 1060–1064 (Dec. 1956).

Some physical properties of gallium-copper-tin alloys. Denton L. Smith, Harold J. Caul, and William T. Sweeney. J. Amer. Dental Assoc. (222 E. Superior St., Chicago 11, Illinois) **53,** 677–685 (Dec. 1956).

Spectroscopic observations on pentaborane-air flames and explosions. W. G. Berl, E. L. Gayhart, H. L. Olsen, H. P. Broida, and K. E. Shuler. J. Chem. Phys. (American Institute of Physics, 57 E. 55th St., New York 22, N. Y.) **25,** No. 4, 797 (Oct. 1956).

A method for measuring the mucosal surface contours of impressions, casts and dentures. N. W. Rupp, George Dickson, M. E. Lawson, Jr., and W. T. Sweeney. J. Am. Dental Assoc. (222 E. Superior St., Chicago 11, Ill.) **54,** 24–32 (Jan. 1957).

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300
(GPO)

TECHNICAL NEWS BULLETIN

U. S. DEPARTMENT OF COMMERCE
SINCLAIR WEEKS, *Secretary*
NATIONAL BUREAU OF STANDARDS
A. V. ASTIN, *Director*

June 1957 **Issued Monthly** **Vol 41, No. 6**

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price, domestic $1.00 a year; 35 cents additional for foreign mailing; single copy, 10 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (March 29, 1956).

Contents

	Page
Ultra-high-strength steel	81
Atmospheric radio noise recording program	83
Electronic computer study of English syntax patterns	84
Hydraulic research in the United States	86
Powders for low-temperature insulation	87
Crystal chemistry of tooth and bone mineral	88
High-frequency magnetic measurements	91
Addendum to Radiation Handbook 60	92
A simple transistor beta tester	93
Distribution of certain short-lived radioisotope standards	93
Handbook of mathematical tables	94
New radiation handbook	95
Publications of the National Bureau of Standards	95

NBS Publication (*continued*)

Behaviour of "pure gum" rubber vulcanisates in tension. G. M. Martin, F. L. Roth and R. D. Stiehler. Trans. Inst. Rubber Ind. (Secy., 12 Whitehall, London SW1, Eng.) **32**, No. 6, 189–203 (1956).

Characteristics of metal-clad laminates. D. S. Hoynes. Elec. Mfg. (The Gage Publishing Co., 1250—6th Ave., New York 20, N. Y.) **59**, No. 4, 110 (Apr. 1957).

Mathematics.—Commuting bilinear transformations and matrices. Olga Taussky and John Todd. J. Wash. Acad. Sci. (Custodian and Subscription Mgr. of Publications, U. S. National Museum, Washington 25, D. C.) **46**, No. 12, 373–375 (Dec. 1956).

Dimensions, units, and standards. A. G. McNish. Phys. Today (American Inst. of Physics, 57 E. 55th St., New York 22, N. Y.) **10**, No. 4, 19–25 (Apr. 1957).

Disaster monitoring with amateur photographic film and with dental X-ray film. Margarete Ehrlich. Radiology. (Can. Radiological Society of N. America, Business Mgr., 713 E. Genesee St., Syracuse 2, N. Y.) **68**, No. 2, 251–254 (Feb. 1957).

Measurement of a service area for television broadcasting. R. S. Kirby. Trans. IRE (American Inst. of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.) PGBTS-**7**, 23–30 (Feb. 1957).

Measured statistical characteristics of VLF atmospheric radio noise. A. D. Watt and E. L. Maxwell. Proc. IRE (American Inst. of Electrical Engineers, 33 W. 39th St., New York 18, N. Y.) **45**, 55–62 (Jan. 1957).

On the measurement of the conductivity of a fluid contained in a cylindrical vessel. J. R. Wait. Can. J. Technol. (National Research Council, Ottawa, Can.) **34**, 410–412 (Jan. 1957).

Reliability starts with circuit design. James H. Muncy. Aviation Age. (The Conover-Mast Pub., Inc., 998 Nat'l Press Bldg., Washington 6, D. C.) **27**, No. 1, (Jan. 1957).

Insulating concretes. R. C. Valore, Jr. J. Am. Concrete Inst. (American Concrete Institute, 18263 W. McNichols Rd., Detroit 19, Mich.) **28**, No. 5, (Nov. 1956). Proc. V. **53**.

Calibration of the portable Swedish free-air chamber equipment at the U. S. National Bureau of Standards. R. Thoraeus and H. O. Wyckoff. Acta Radiol. (P. A. Norstedt & Soner, Tryckerigatan 2, Stockholm (2), Sweden) **46**, 6 (Dec. 1956).

Solar radio astronomy at the National Bureau of Standards. Paper presented at Proc. of the 7th Annual Western Amateur Astronomers Convention at Yosemite Park, California. (Aug. 19–21, 1955). Vernon H. Goerke.

Shielding of a transient electromagnetic dipole field by a conductive sheet. J. R. Wait. Can. J. Phys. (National Research Council, Ottawa, Canada) **34**, 890–893 (1956).

Publications for which a price is indicated are available only from the Government Printing Office, Washington 25, D. C. (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

Patents

(The following U. S. Patents have been granted to NBS inventors. Assigned to the United States of America, as represented by the Secretary of the Department noted in parentheses.)

No. 2,779,287. January 29, 1957. Contact fuze. Laurence M. Andrews and Jacob Rabinow (Army).

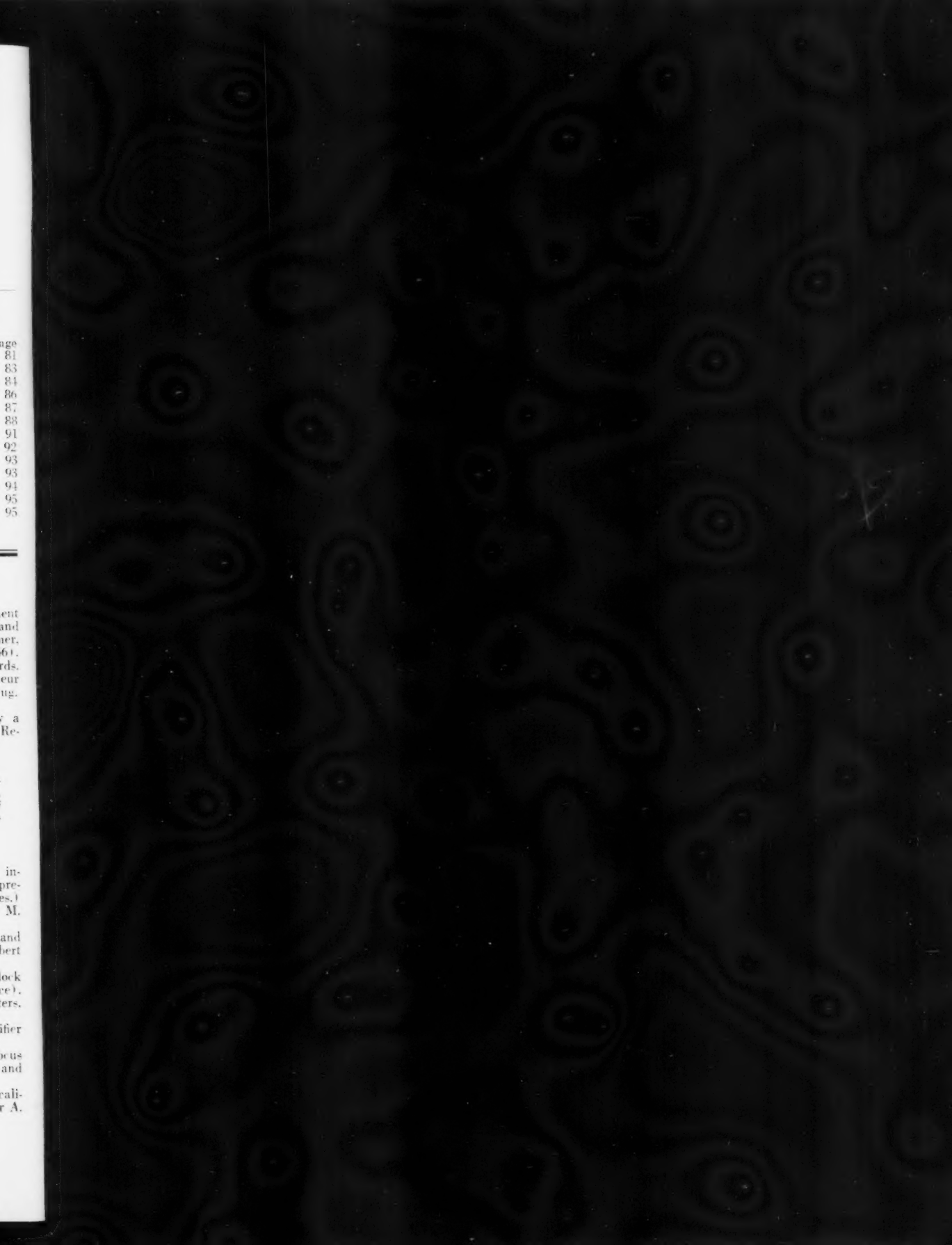
No. 2,779,760. January 29, 1957. Lithium maltobionate and process for making same. Horace S. Isbell and Robert Schaffer (Commerce).

No. 2,781,273. February 12, 1957. Method of making block talc and related materials. William J. Koch. (Commerce).

No. 2,782,377. February 19, 1957. Micropotentiometers. Myron C. Selby. (Commerce).

No. 2,783,314. February 26, 1957. Square-wave amplifier circuits. John H. Reaves (Commerce).

No. 2,784,640. March 12, 1957. Method for determining focus and quality of searchlight reflectors. John A. LeReche and Theodore H. Projector. (Navy).

No. 2,786,105. March 19, 1957. Telemetering in-flight calibrator. Myron G. Pawley, Leland L. Parker, and Walter A. Hereth. (Navy).

U. S. GOVERNMENT PRINTING OFFICE: 1957